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NONFINANCIAL SECTORS DEBT AND THE U.S. GREAT MODERATION

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Abstract

During the Great Moderation, borrowing by the U.S. nonfinancial sectors structurally exceeded GDP growth. Using flow-of-fund data, we test the hypothesis that this measure of debt buildup was leading to lower output volatility. We estimate univariate GARCH models in order to obtain estimates for the volatility of output growth. We estimate a VAR model over two periods, 1954-1978 (before the Great Moderation) and 1984-2008 (during the Great Moderation). We test whether the relation between credit growth and GDP volatility changed between the two periods, controlling for the stance of monetary policy, for inflation, and for the endogeneity of credit to growth. Results from Granger causality tests, impulse response functions, forecast error variance decompositions and a counterfactual simulation suggest that credit growth in the nonfinancial sectors in excess of output growth was among the causal factors of the decline in output volatility during the Great Moderation. We discuss implications.

Key Words: great moderation, credit, VAR, causality

JEL codes: E44, C32, C51, C52

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NONFINANCIAL SECTORS DEBT AND THE U.S. GREAT MODERATION

1. Introduction

This paper finds that credit growth in the nonfinancial sectors in excess of output growth was among the causal factors of the decline in output volatility during the Great Moderation. In the mid-1980s, two shifts occurred in the US economy. The first was that borrowing by the nonfinancial sectors increased strongly within a few years, to a level that was structurally above the level of growth. It remained high for over two decades, until the 2007 crisis. The second was that macroeconomic volatility declined strongly within a few years.[1] This 'Great Moderation' lasted for more than two decades, until the 2007 crisis. Access to credit may decrease output fluctuations since "credit demand appears to contain a significant countercyclical component, which arises from the desire of households and firms to smooth the impact of cyclical variations in income on spending or production" (Bernanke and Gertler, 1995:44).

In this paper we pursue this explanation. We use the 'Z' tables of the U.S. flow of funds statistics to observe borrowing by the nonfinancial sectors in excess of growth. We so obtain a measure for the growth in indebtedness of the nonfinancial sectors at the macro level, which we link to output volatility at the macro level. We hypothesize that the growth in this 'excess' credit growth in the nonfinancial sectors was among the Granger-causal factors of the lower volatility of output during the Great Moderation. It bears emphasis that we test for Granger causation, which implies that " [t]he cause contains information about the effect that is unique, and is in no other variable is informative on sequence in time, rather than "true causality", as Granger himself mentioned in his Nobel speech in 2003 (Granger, 2003) [2]. Our hypothesis is related to a number of financial-sector explanations of the Great Moderation, and consistent with a wider literature on credit and macro volatility. But we break new ground in two areas.

[1] The Great Moderation era saw declines in the volatility of a number of macroeconomic variables in the U.S., as in many other countries (Bernanke, 2004; Cecchetti and Krause, 2006; Ćorić, 2012). The standard deviation of U.S. quarterly growth and inflation declined by half and by two thirds since 1984, respectively (Blanchard and Simon, 2001; Carlstrom et al., 2009). Stock and Watson (2002) find that the standard deviation of U.S. GDP growth declined from 2.6-2.7% in the 1970s and 1980s to 1.5% in the 1990s. Also employment volatility strongly declined (Kim and Nelson, 1999; Warnock and Warnock, 2000).

[2] Granger continued to say that " [a]t that time, I had little idea that so many people had very fixed ideas about causation, but they did agree that my definition was not "true causation" in their eyes, it was only "Granger causation". I would ask for a definition of true causation, but no one would reply." (Granger, 2003:366).

First, no study to date has directly analyzed the link between output volatility during the Great Moderation and borrowing by the nonfinancial sectors - that is, excluding borrowing for investment in the 'finance, insurance and real estate' sectors (or 'FIRE' sectors, in the classification of the National Income and Product Accounts). A number of studies have focused on FIRE-sector wealth buildup resulting from financial innovations and its possible effect on output volatility moderation, through a wealth effect on income (e.g. Den Haan and Sterk, 2011). The channel through which debt-financed wealth accumulation affects output volatility is different from the effect of debt-financed activity, which we analyze.

A second contribution is that we observe not just credit flows (as other studies do), but the growth in borrowing by the nonfinancial sectors in excess of output growth. We so focus on the growth in the debt-to-GDP ratio that is due to borrowing by the nonfinancial sectors. This goes beyond simply testing for the effect of credit on volatility. Other studies have shown that credit flows to the nonfinancial sectors normally move together with output growth (Biggs et al., 2010; Board, 2012), and that credit moderates industrial output volatility (Larrain, 2006). A special feature of the Great Moderation was that growth in credit flows to the nonfinancial sectors structurally exceeded nominal GDP growth (as we show in the next section) - even when excluding the growth in credit to finance, insurance and real estate (i.e. not to the nonfinancial sectors), where most of the credit growth was occurring. Plausibly, credit growth in the nonfinancial sectors has a more direct impact on output volatility. This has not been analyzed to date.

Our empirical approach is to first estimate the conditional standard deviation of output growth. Using this obtained measure for output volatility, we then estimate a number of reduced-form VAR models for quarterly data over 1984Q1-2008Q1 (the results are robust to variations in the time bounds of the Great Moderation). We examine lags of excess credit growth in a system of equations with (obtained) real output growth volatility, the inflation rate and the federal funds rate. We find robust evidence that the increased growth of borrowing beyond GDP growth was a Granger-causal factor in the greater macroeconomic tranquility that characterized the Great Moderation. We then ask if this was also the case before the Great Moderation. In an analysis of a 1954Q3-1978Q4 sample (i.e. one which ends well before the earliest dating of the Great Moderation), we fail to find Granger causality between 'excess' credit growth and output volatility. This may be either because excess credit growth was much smaller before the Great Moderation, as we document, or because the dependence of output volatility on excess credit growth was lower. In either case, there is evidence that the rate of borrowing in the nonfinancial sectors beyond GDP growth was a Granger-causal factor in greater macroeconomic tranquility of the Great Moderation, which it was not before.

The paper is organized as follows. The next section presents trends in U.S. credit market instruments and in output growth. In section 3 we make connections to the literature. In section 4 we present the methodology. Section 5 presents the data and reports results. Section 6 concludes with a summary, reflections and suggestions for future research.

2. Postwar Trends in the U.S. Credit Market Lending

Figure 1 shows the long-term development of the growth in credit in the U.S. The stock of credit (comprising both bank and nonbank lending) relative to GDP quadrupled from 1952 to 2008. Most of that growth occurred during the Great Moderation and credit flows to the finance, insurance and real estate sectors accounted for most of the increase.[3] Also credit to the nonfinancial sectors (that is, credit to nonfinancial business, to government and nonmortgage credit to households) rose strongly during the Great Moderation: from 87% of GDP in 1952 to 99% in 1984 and to 143% of GDP in 2008. This implies a more than threefold rise in the annual growth rate of the (nonfinancial-sectors) credit-to-GDP ratio, from 0.4% in 1952-1983 to 1.4% annually over 1984-2008. Figure 2 plots the growth in credit to the nonfinancial sectors and the growth in nominal GDP. We compute the difference between the two growth rates and label this variable "excess credit growth".

[Figure 1 HERE]

[Figure 2 HERE]

The Federal Reserve notes in its 'Guide to the Flow of Funds' that "over long periods of time there has been a fairly close relationship between the growth of debt of the nonfinancial sectors and aggregate economic activity" (Board, 2012:176). The growth in nonfinancial sectors borrowing creates purchasing power which adds proportionally to GDP, because "loans cause deposits and those deposits cause an expansion of GDP transactions" - at least if those deposits are expended on goods and services rather than assets (Caporale and Howells, 2001; also Minsky, 1982; Levine, 2004; Ang, 2008). This is apparent in the flat part of the graph in Figure 1 on the left, before the Great Moderation. In contrast, around the start of the Great Moderation, the growth in the stock of

[3] By the end of the Great Moderation, credit to the finance, insurance and real estate sectors had increased from 30% of GDP in 1952 (the start of the data series) to 81% of GDP in 1984, to 260% of GDP in 2008. Most of this rise, in turn, was due to growth in mortgage debt. After the Great Moderation, FIRE-sector debt dropped sharply relative to GDP.

credit to the nonfinancial sectors exceeds the growth in nominal GDP so that their ratio rose. The difference, which remained positive for most of the Great Moderation, indicates borrowing which is (by definition) not itself expended on domestic goods and services - if it was, this would have raised GDP growth to the level of credit growth.

Figure 3 plots the cumulative difference between the growth rates of nominal GDP and credit to the nonfinancial sectors. This "excess credit growth" cumulation was mostly negative between 1952 and 1970, when the economy was growing faster, on average, than the growth of lending to the nonfinancial sectors. Through the 1970s cumulative "excess credit growth" remained at a positive but fairly constant and low level. It took off in the early 1980s and remained high (and increasing in most years) during the Great Moderation.

[Figure 3 HERE]

There are several possible ways in which the nonfinancial sectors' debt growth can rise above GDP growth, and so deviate from the long-term parity noted in the Flow of Funds guide – for instance, trends in net financial asset acquisition or in debt-financed imports. Whether or not these or other channels operated is not the focus of this paper, and we relegate a brief discussion of possible channels to Appendix B. In any case, an increase in borrowing relative to output may decrease output fluctuations since it allows "households and firms to smooth the impact of cyclical variations in income on spending or production" (Bernanke and Gertler, 1995:44). This is also suggested by, for instance, Davis and Kahn (2008) who find that an important part of the decline in macro volatility is explained by changes in aggregate volatility in the durable goods sector, but *without* a decline in the uncertainty of incomes. This is understandable if part of durable goods consumption was financed with debt, not income. Their finding is consistent with the greater credit availability that was typical of the Great Moderation (as also Dynan et al., 2006 document), which would also have the effect of loosening the link between the dynamics of income and consumption.

3. Connections to the Literature

That credit stabilizes output is no new finding. We already noted studies by Bernanke and Gertler (1995) on the countercyclical tendency of consumer credit and by Larrain (2006) on the stabilizing properties of credit with respect to industrial output. Iacoviello (2005) estimates a monetary business cycle model with nominal loans and finds that "nominal debt dampens supply shocks, stabilizing the economy under interest rate control" (Iacoviello, 2005:739). Jermann and Quadrini (2006) similarly show in a general equilibrium model how innovations in financial markets can generate a lower volatility of output, together with a higher volatility in the financial structure of firms. "Credit View" literature (Bernanke and Blinder, 1988; Bernanke, 1993; Bernanke and Gertler, 1995) and accelerator models (Kiyotaki and Moore, 1997; Campbell, 2005) theorize how the credit system may either amplify or dampen exogenous shocks. A broader strand of literature connects credit conditions to the business cycle and the economy's volatility (e.g. Bliss and Kaufmann, 2003; Mendicino, 2007), making the general point that financial development tends to stabilize growth (Easterly et al., 2000).

It is therefore unsurprising that among the many explanations of the Great Moderation, a good number involve the financial sector.[4] Financial innovations and deregulations of lending practices and loan markets during the Great Moderation such as relaxed collateral constraints, lower down payments, and lower rates of amortization for durable goods purchases on household borrowing (Campbell and Hercowitz, 2005) affected consumer spending, housing investment, and business fixed investment (Dynan et al. (2006). Guerron-Quintana (2009) develops a model of the demand for money with portfolio adjustments to suggest that the Great Moderation can be partially attributed to financial innovations in the late 1970s. His model accounts for almost one-third of the observed decline in the volatilities of output, consumption, and investment.

The present paper is consistent with each of these finance-driven accounts of the Great Moderation (which operated in conjunction with other, nonfinancial factors, to be sure). What it adds is a focus on growth of debt relative to output, and which was connected to nonfinancial-sectors activity, rather than to asset and property markets (as in Den Haan and Sterk, 2011). The testable implication we suggest is that *there was Granger causality from this 'excess credit growth' measure to the volatility of output growth during the Great Moderation, different from the pre-Great Moderation years*. Note that this may be either because before the Great Moderation excess

[4] Research has identified as possible causes for the Great Moderation better inventory management (McConnell and Perez-Quiros, 2000; Kahn et al., 2002; McCarthy and Zakrajsek, 2007), labor market changes and demography (Jaimovic and Siu, 2009), oil shocks (Nakov and Pescatori, 2010), changed responses to those and other shocks (Gambetti et al., 2008) or broader factors such as institutions (Acemoglou et al., 2003; Owyang et al. (2007), external balances (Fogli and Perri, 2006), the size of the economy (Canning et al., 1998), and development levels (Acemoglu and Zilibotti, 1997; Easterly et al., 1993)- or simply to "good luck" (Ahmed et al., 2002; Cogley and Sargent, 2005; Primiceri, 2005; Sims and Zha, 2006; Benati, 2008; Gambetti et al., 2008; Benati and Surico, 2009). Part of the moderation in output volatility may be also be due to changing responses to monetary shocks (Clarida et al., 2000) and improvements in monetary policy (Bernanke, 2004; Lubik and Schorfheide, 2003; Boivin and Giannoni, 2006; Akram and Eitrheim, 2008).

credit growth was much smaller (Figure 2), or because the dependence of output volatility on excess credit growth was lower.

4. Methodology

Output growth volatility may be measured by the conditional variance estimated in univariate or multivariate GARCH models (Bollerslev, 1986 based on Engle's (1982) ARCH model; Engle and Kroner, 1995).[5] To obtain volatility estimates, we first test for the existence of ARCH effects (i.e. volatility clustering), which causes volatility levels to correlate positively over time and suggest the estimation of an ARCH(p) model (Engle, 1982). The conditional mean equation is then:

$$y_t = \mu + \sum_{h=1}^{z} \varphi_h y_{t-h} + \varepsilon_t,\ \varepsilon_t \mid \psi_{t-1} \sim N\left(0, \sigma_t^2\right) \tag{1}$$

where, y_t, μ, φ_h, ε_t are vectors of the dependent variable, intercept, autoregressive term and the innovation vector, respectively, and ψ_{t-1} is the information set at time *t-1*. Given an estimate for the conditional mean, this allows us to obtain the conditional variance in the equation:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 \tag{2}$$

where σ_t^2 is the conditional variance, α_0 the intercept and α_i the ARCH terms of the variance equation (with $i = 1,..., p,$). The estimated variance should be positive; therefore we impose $\alpha_0 > 0$ and $\alpha_i \geq 0$ for $i \geq 1$. In addition, since we require long-run stationarity, we impose the condition $\sum_{i=1}^{p} \alpha_i < 1$.[6]

Given the existence of ARCH effects, it is often useful to estimate the more parsimonious GARCH model (Bollerslev, 1986) which allows for a flexible lag structure. A GARCH(p,q) model accommodates autoregressive as well as moving-average components in the heteroskedastic variance. The equation for heteroskedastic variance which replaces equation (2) is then:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 \tag{3}$$

[5] An analytical survey of multivariate GARCH models is in Bauwens et al. (2006).
[6] Nelson and Cao (1992) provide analytically the inequality constraints for univariate GARCH models.

where β_j now denotes the GARCH component parameters, with $\beta_j \geq 0$ and $\sum_{i=1}^{p}\alpha_i + \sum_{j=1}^{q}\beta_j < 1$ for $i \geq 1$ and $j \geq 1$.

Because of the squared lagged error term in equation (3), the conditional variance is a function of the magnitudes of lagged residuals, but not of their signs (symmetric response of volatility to positive and negative shocks). In reality, a negative shock ("bad" news) tends to increase volatility more than a positive shock ("good" news) of the same magnitude, especially in financial time series. Accounting for this asymmetric responses (or 'leverage effect'), we estimate two asymmetric specifications for the conditional variance, both widely used. The first is the Exponential GARCH (EGARCH) model (Nelson, 1991) which does not require non-negativity constraints:

$$ln\left(\sigma_t^2\right) = \alpha_0 + \sum_{j=1}^{q}\beta_j \, ln\left(\sigma_{t-j}^2\right) + \sum_{i=1}^{p}\alpha_i \left|\varepsilon_{t-i}/\sigma_{t-i}\right| + \sum_{k=1}^{r}\lambda_k \left(\varepsilon_{t-k}/\sigma_{t-k}\right) \tag{4}$$

In equation (4), the conditional variance is in log-linear form. So regardless of the magnitude of $ln\left(\sigma_t^2\right)$, the implied value of σ_t^2 is non-negative. It is therefore possible for the coefficients to take negative values. Also, instead of using the value of ε_{t-i}^2 as in equation (3) the EGARCH model uses the standardized value of ε_{t-i}. This allows for a more natural interpretation of the size and persistence of shocks (Nelson, 1991). A third advantage of the EGARCH model is that it allows for leverage effects, as noted. These effects occur if $\lambda_k < 0$.

Another option is to estimate a general form of the Threshold ARCH model (Zakoian, 1994), which is the Threshold GARCH (or TGARCH) model (Glosten et al., 1993). The TGARCH model has an additional term accounting for possible asymmetries. The conditional variance is now given by:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p}\alpha_i\varepsilon_{t-i}^2 + \sum_{j=1}^{q}\beta_j\sigma_{t-j}^2 + \sum_{k=1}^{r}\gamma_k d_{t-k}\varepsilon_{t-k}^2 \tag{5}$$

Here we impose the non-negativity constraints: $\alpha_0 \geq 0$, $\alpha_i \geq 0$, $\beta_j \geq 0$, and $\sum_{i=1}^{p}\alpha_i + \sum_{k=1}^{r}\gamma_k \geq 0$. In equation (5), d_{t-k} is a dummy variable which is equal to one if $\varepsilon_{t-k} < 0$ and equal to zero if $\varepsilon_{t-k} \geq 0$. This ensures that if $\gamma_k > 0$, then negative shocks will have larger effects on volatility than positive shocks. If $\gamma_k \neq 0$, then there is a threshold effect.

Once we obtain an estimate for output volatility (i.e. the conditional standard deviation), we move on to the aim of this paper, which is to analyze Granger causality between output volatility and other variables in a Vector Autoregressive (VAR) model. Since we have no prior on causality, all variables are treated as endogenous, allowing the value of a variable to depend on its own lags and on the lags of all the other variables in the model. The VAR specification is:

$$y_t = \mathrm{A}_0 + \mathrm{A}_1 y_{t-1} + ... + \mathrm{A}_p y_{t-p} + \varepsilon_t \tag{6}$$

where y_t is an (n x 1) vector with the n variables included in the VAR (endogenous variables), A_0 reflects an (n x 1) vector of intercept terms, A_i denote (n x n) matrices of coefficients (with $i=1,\ldots p$) and ε_t is an (n x 1) vector of error terms.

We then conduct Granger causality tests (Granger, 1969) and estimate impulse response functions (IRFs). IRFs represent the moving average evolution of the system, describing how one variable responds to a shock to itself or other variables. Sims (1980) suggests that examining IRFs might be the most effective way of exploring Granger causality in multivariate frameworks.[7] Another way to do this is to characterize the dynamic behavior of the VAR in a forecast error variance decomposition analysis. And third, we present a counterfactual analysis.

5. Data and Empirical Results

We use quarterly data for the U.S. over two subsamples, 1954Q3-1978Q4 (before the Great Moderation) and 1984Q1-2008Q1 (during the Great Moderation).[8] We calculated the logarithm of real GDP (RGDP) and as control variables we include the Federal funds rates (FR) – which is

[7] Note that while Granger causation is not identical to economic causation - especially not in the case of forward-looking agents taking out credit -it is one of the ways to assess evidence for economic causation which is open to us in the context of this model. We compute orthogonalized impulse responses using Cholesky decompositions (Sims, 1980). IRFs trace the effect of a 1 standard deviation shock to one of the innovations (error terms) on current and future values of the endogenous variables. A shock to the *i*th variable is so transmitted to the other endogenous variables in the VAR system as well as the *i*th variable itself.

[8] We applied the Chow test for structural breaks over the whole period 1954Q3-2008Q1 and found that any quarter in 1980Q1-1983Q4 is a potential breakpoint in output volatility. This is consistent with Boivin and Giannoni (2006) who report that there is no robust breakpoint at which the Great Moderation would have started. Fang and Miller (2008) show that the time-varying variance of output falls sharply or even disappears once they incorporate a one-time structural break in the unconditional variance of output starting 1982 or 1984. The literature uses any year between the late 1970s and 1984 at the latest. To test sensitivity to choice of break point, we chose 1981Q2 as alternative breakpoint and we re-estimated the VAR. The results are similar to those obtained for the periods 1954Q3-1978Q4 and 1984Q1-2008Q1 and are available upon request.

stationary in first difference (I(1)) - and inflation (INF), measured by the real GDP deflator.[9] Our fourth variable is excess credit growth (EXCRED), the difference between the growth rates of nominal credit to the nonfinancial sectors and of nominal output. We refer to Appendix A for details of the construction of EXCRED. With these four variables in a VAR framework, we control for the stance of monetary policy, for inflation, and for the endogeneity of credit to growth (as well as for other endogeneities).

After testing for stationarity, we examine the presence of ARCH effects (clustered volatility) by conducting the ARCH Lagrange Multiplier (ARCH-LM) test, for 1 to 12 lags (Engle, 1982). Table 1 reports descriptive statistics and values of the ARCH-LM statistic for the two subsamples.

[Table 1 HERE]

All variables have positive growth rates (differenced logs) on average. All variables tend to be more volatile before the beginning of the Great Moderation than during the Great Moderation. The distribution of inflation exhibits positive skewness with few high values in both subsamples; the opposite holds for the remaining variables. Further, the kurtosis (or "peakedness") statistics for the distributions of all the variables show more deviations from the normal distribution in the first subsample than in the second. The ARCH-LM test shows that evidence of ARCH effects in the squares of real output growth rate in both subsamples.[10]

We estimate four (symmetric and asymmetric) GARCH models in order to obtain the conditional standard deviation of RGDP, accounting for autoregressive terms (see equations 1-5). Given the skewness and kurtosis of the log difference of RGDP, we assume that the error term of equation (1) is t-student distributed. The parameters of the univariate GARCH models are therefore estimated by maximizing the log-likelihood function:

[9] We thank Wouter den Haan for making the data available; see Den Haan and Sterk (2011). We apply the following stationarity tests to the logs of the variables: (i) Kwiatkowski–Phillips–Schmidt–Shin (KPSS) (Kwiatkowski et al., 1992), (ii) Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979) and (iii) Phillips and Perron (PP) (Phillips and Perron, 1988). For tests (i) and (iii), the lag length was selected by the kernel-based estimator of the frequency zero spectrum, which is based on a weighted sum of the covariances. For test (ii) the selection of the number of lags in the test equations is according to the Schwartz Information Criterion (SIC). Stationarity is tested at 1%, 5%, 10% significance levels and the time trend has been taken into account in the test equation. Unit root test results are available on request.

[10] We only test for ARCH effects in real GDP growth as we are interested in its volatility and not in the volatility of the other variables.

$$l_t = -\frac{1}{2}\log\left(\frac{\pi(\nu-2)\Gamma(\nu/2)^2}{\Gamma((\nu+1)/2)^2}\right) - \frac{1}{2}\log\sigma_t^2 - \frac{(\nu+1)}{2}\log\left(1+\frac{\varepsilon_t^2}{\sigma_t^2(\nu-2)}\right) \qquad (7)$$

where Γ(.) is the gamma function and v is the degree of freedom (v>2). The log-likelihood function for the conditional t distribution converges to the log-likelihood function of the conditional normal GARCH model as $v \to \infty$.

We first select the models which meets the non-negativity constraints and stationarity conditions (in the symmetric GARCH models), and/or which support the existence of leverage or threshold effect (in the asymmetric GARCH models). Table 2 reports the three AR-GARCH models that pass the above tests. From this subset, the preferred GARCH model is selected according to the minimum value of the Schwarz Information Criterion (SIC).[11] The SIC value indicates that the conditional variance of output growth (and subsequently the conditional standard deviation) is best captured by a symmetric GARCH model - specifically, the AR(2)-GARCH(1,1).[12] The Ljung-Box statistic indicates that the estimated model is well-specified once it does not suffer from remaining autocorrelation (Q(p)) and remaining ARCH effects (Q^2(p)).

[Table 2 HERE]

Having obtained the conditional standard deviation estimates for the volatility of real output growth, we then estimate a number of reduced-form VAR models on quarterly data for the two subsamples 1954Q3-1978Q4 and 1984Q1-2008Q1. We examine whether lags of excess credit growth (EXCRED) matter to the volatility of real output growth (denoted σ_{dlrgdp}). Other variables in the system are the inflation rate (INF) and the federal funds rates (FR), as in Den Haan and Sterk (2011). We estimate VAR(p) models with $p=1,\ldots 12$. The model selection criterion is again the minimum SIC value.[13] This procedure yields a VAR(1) model for both subsamples.[14] To examine

[11] We used 1-12 lags for the estimation of the AR(p)-(A)Symmetric GARCH models. Three models meet the criteria of nonnegativity constraints on the conditional variance coefficients (apart from EGARCH model for which such restrictions are not necessary) and residual diagnostics of no remaining ARCH effects and remaining autocorrelation. The coefficient λ1 in the AR(2)-EGARCH(1,1) model, which reflects the asymmetric effect on the conditional variance, is negative supporting the existence of leverage effect. The coefficient γ1 in the AR(2)-TGARCH(1,1) model denotes the asymmetric term in the conditional variance and the positive sign reflects that negative shocks will have larger effects on volatility that positive shocks.

[12] Several conditional variance specifications have been estimated and the GARCH(1,1) performs better.

[13] We estimated the VAR including also output growth. The results do not change qualitatively and are available upon request. We thank an anonymous referee for this suggestion.

[14] Although the lag order of the VAR is short, the dynamic behavior of the variables can be captured sufficiently in the first subsample. We tried also VAR(2) as indicated by Akaike Information Criterion (AIC); the qualitative results do not change. In the second subsample VAR(1) is indicated by both information criteria.

the causal effects of the variables under investigation, we conduct Granger causality tests, reported in Table 3.

[Table 3 HERE]

We find that interest rates were more responsive to inflation during the Great Moderation than was the case before. This plausibly reflects the adoption of inflation targets in monetary policy. Interest rates themselves exhibit bidirectional causality with output volatility in the Great Moderation, and unidirectional causality (from interest rates to output volatility) before. Also, we find Granger causality from excess credit growth to changes in interest rate in both subsamples. As to our hypothesis, the first two rows of Table 3 show unidirectional causality from excess credit growth to output volatility in, but not before the Great Moderation. This is consistent with the hypothesis that during the Great Moderation, borrowing by the nonfinancial sectors in excess of GDP growth moderated GDP fluctuations, which it did not before.

We also study IRF analyses over 12 periods in Figures 4 and 5 and forecast error variance decomposition, separately for both subsamples in Figures 6 and 7. For ease of overview, we summarize the key findings in Tables 4 (IRFs) and 5 (variance decomposition analysis).[15]

[Figure 4 HERE]

[Figure 5 HERE]

[Figure 6 HERE]

[Figure 7 HERE]

[Table 4 HERE]

[Table 5 HERE]

There are three significant effects in the IRFs. Most relevant to our hypothesis, we find that a one-standard deviation shock in excess credit growth impacts negatively (with decreasing strength) on output volatility, after the second period. In line with this, the forecast error variance decomposition analysis shows that a substantial part of output growth volatility during the Great Moderation is attributable to excess credit growth, whereas almost nothing of it was explained by excess credit

[15] The decomposition of the forecast error variance of inflation and the federal funds rate are not reported in the table and the Figures. They are available on request.

growth before the Great Moderation. Conversely, inflation and the interest rate both explain substantial parts of output volatility before the Great Moderation and much less during the Great Moderation.[16] This is consistent with the hypothesis that the rise in excess credit growth is among the causes of the Great Moderation change in output volatility. It is important to emphasize that the differences between pre- and during Great Moderation results may be due to either less excess credit growth or because the dependence of output volatility on excess credit growth was lower before the Great Moderation.

We also run a counterfactual analysis where we take *during*-Great Moderation VAR parameter estimates and then apply these to *pre*-Great Moderation variables values, in order to compute output volatility forecast in each quarter. We contrast this to actual output volatility forecast during the Great Moderation. This exercise asks how much larger output growth volatility in the Great Moderation would have been, had the relations between excess credit growth and the other variables with output volatility not changed in the way it did.[17] Figure 8 presents the results.

[Figure 8 HERE]

Figure 8 shows that output growth volatility is 0.88% in the counterfactual simulation, compared to the actual 0.57% average. This result suggests that actual output growth volatility was about one third lower than what it would have been, had the relations between excess credit growth and other variables with output growth volatility not changed in the way it did. This one-third reduction in output growth volatility compares to reported declines in the standard deviation of U.S. quarterly growth by about one half since 1984 (Blanchard and Simon, 2001; Stock and Watson 2002). On this count, the counterfactual simulation results suggest that the present paper identifies a mechanism behind the Great Moderation that is not only statistically significant, but also non-negligible in magnitude.

[16] The results for variance decomposition and IRF remain qualitatively the same if we change the order of entering variables in the VAR.

[17] Note that the outcome of this procedure should not be interpreted as strictly isolating the effect of excess credit growth on output volatility. The possible impacts, if any, of the other variables in the system on output volatility are included. That is, in the counterfactual simulation all parameter estimates (not just the excess credit parameter) have counterfactual (pre-Great Moderation) values, since the parameters are estimated in a system. But the Granger test and IRF results suggest that of the four variables, the changes in effect of excess credit on output volatility (both directly and through the other variables) were the most significant.

6. Summary, Discussion and Conclusions

In the mid-1980s, two shifts occurred in the US economy. The first was that macroeconomic volatility declined strongly within a few years. This ‘Great Moderation’ lasted for more than two decades, until 2007. The second was that borrowing by the nonfinancial sectors increased strongly within a few years, to a level that was structurally above the level of growth. It remained high for over two decades, until 2007. Since access to credit may decrease output fluctuations, we hypothesize that during the Great Moderation borrowing by the nonfinancial sectors in excess of GDP growth moderated GDP fluctuations.

No study to date has directly analyzed the link between output volatility during the Great Moderation and borrowing by the nonfinancial sectors. The effect of debt-financed wealth accumulation on volatility is different from the effect of debt-financed activity, which we analyze. A second contribution is that we observe not just credit flows (as most other studies do), but the growth in borrowing by the nonfinancial sectors in excess of output growth (or ‘excess credit growth’). Using flow-of-fund data, we focus on the indebtedness of the nonfinancial sectors.

We show that excess credit growth was persistently positive during most of the Great Moderation, which it was not before. We test the hypothesis that this Granger-caused lower output volatility. We estimate univariate GARCH models in order to obtain estimates for the volatility of output growth. We use this obtained volatility in a VAR model with the volatility of output growth, excess credit and control variables (interest rate and inflation) over two periods, 1954-1978 (before the Great Moderation) and 1984-2008 (during the Great Moderation). Results from Granger causality tests, impulse response functions, forecast error variance decompositions and a counterfactual simulation suggest that excess credit growth was Granger-causing the decline in output volatility during the Great Moderation, and that the magnitude of the effect on output volatility was non-negligible.

As to the interpretation of these results, a focus on debt growth is one way to connect (as in Bean, 2011) the Great Moderation to the (2007) ‘Great Crash’ and the ‘Great Recession’ that followed. Bean (2011) discusses how low volatility in real and financial variables induced more debt-financed investment and risk taking than would otherwise have occurred in the decades preceding the Crash. This more cautionary view on credit growth also fits in with Minsky’s (1982) theory that ‘stability is destabilizing’, precisely because of the buildup in leverage that it encourages. Kemme and Roy (2012) show that the U.S. mortgage-driven house price boom was a good predictor of the crisis. Cross-country empirical results point in the same direction. Akram and Eitrheim (2008) find that stabilization, not acceleration of credit growth enhances stability in both inflation and output in the long run. Arcand et al. (2012) find that there can be 'too much finance': above a threshold level of the credit-to-GDP ratio, the growth effect of credit declines and turns negative. Cecchetti et al. (2012) likewise conclude that beyond a certain level, debt is a drag on growth. Reinhart and Rogoff (2009) find that a common denominator of financial crisis is a credit boom while Jorda et al. (2012) find that more credit-intensive expansions tend to be followed by deeper recessions and slower recoveries. Schularick and Taylor (2012) also analyze that financial crisis are 'credit booms gone bust'.

In line with these recent studies, this paper motivates a link between Moderation and Crash: perhaps there was a moderation of volatility partly due to immoderate credit growth not only in mortgage markets but also in the nonfinancial sectors. Such concerns arose around the same time that the structural decline in U.S. output volatility was first identified (Blanchard and Simon, 2001; Stock and Watson, 2002). Godley (1999) noted that the growth in U.S. private spending was structurally larger than the growth in private sector incomes since the early 1990s, and he wrote that "if … the growth in net lending and the growth in money supply growth were to continue for another eight years, the implied indebtedness of the private sector would then be so extremely large that a sensational day of reckoning could then be at hand." (Godley, 1999:5). These observations, combined with the present study which measures the implied indebtedness of the private sector in the excess credit growth variable, may lead to a re-evaluation of the nature of the Great Moderation.

Appendix A: Data Construction

We construct a measure for credit flows which finance activity in the nonfinancial sectors. Since a large part of credit flows to the nonfinancial sectors are mortgages to households which do not finance activity but finance transactions in real estate assets, excluding mortgages is the most significant difference between our measure and other ‘credit to the private nonfinancial sectors’ measures used in the literature (e.g. Beck et al., 2000, updated in Beck et al., 2013). Obviously mortgages also play a role, albeit a different one, in understanding Great Moderation dynamics (Kemme and Roy, 2012; Grydaki and Bezemer, 2013), but they are not the focus of this paper.

We utilize quarterly data from ‘Z’ tables in the Flow of Funds Accounts. Net credit to the nonfinancial sectors is the difference between stocks of credit market instruments held as assets and as liabilities by the nonfinancial sectors. They are recorded in series FL384004005.Q and FL394104005.Q in Z1, respectively. We subtract mortgage credit recorded in series FL383165005.Q, ‘domestic nonfinancial sectors; total mortgages; liability’. Apart from ‘credit market instruments’ nonfinancial-sectors activity is additionally financed by inter-firm trade credit (FL383070005.Q; see Mateut, 2005 on the role of trade credit), firm-to-customer consumer credit (FL383066005.Q) and ‘other loans and advances’ (FL383069005.Q). We add these credit stocks (which are quantitatively small relative to the credit market instruments stock). Finally, we subtract net financial investment (including home equity withdrawal; Greenspan and Kennedy, 2008).

Appendix B:
On the Links between Excess Credit Growth and Output Volatility

In this Appendix we discuss two possible channels from excess credit growth to reduced output volatility. Every dollar borrowed by the nonfinancial sectors and spent on assets rather than on goods and services increases debt and financial wealth but not activity, in the first instance, and so helps understand the rise in excess credit (Figure 3). If this debt-financed net financial asset acquisition by the nonfinancial sectors occurs in countercyclical manner, this might stabilize GDP. There is extensive evidence (e.g. Krippner, 2005), that during the Great Moderation nonfinancial firms or households increasingly realized their returns in financial transactions (for instance, by borrowing to finance stock repurchases realizing capital gains), which financed consumption or investment.[18]

A second channel through which 'excess credit growth' may contribute to output stability is debt-financed spending on imports. This increases both imports and consumption or investment. Since the rise in imports and the rise in consumption or investment cancel out in the national income definition, debt-financed spending on import does not directly raise GDP but it does increase the debt/GDP ratio in a second-round effect, because of substantial spillover effects of imports on the transport and retail sectors and on activity generally (e.g. Acharya and Keller, 2008), debt-financed imports, if countercyclical to the business cycle, may induce additional activity that stabilizes GDP.

In noting these links of asset acquisition and external balances with excess credit growth, nothing is implied about causality. Looser loan standards and low interest rates may have induced borrowing and consumption, leading to a rise in imports; or vice versa some external shock which decreased external balances may have induced more borrowing. A related paper by Fogli and Perri (2006) posits causality from external balances to lower incentives to accumulate precautionary savings, and an equilibrium permanent deterioration of external balances, consistent with our second channel. Explicitly testing for these causal relations is beset by pervasive endogeneities. It is

[18] Lazonick (2011) presents data on 373 companies in the S&P 500 Index in January 2008 that were publicly listed in 1990. He shows that they expended an annual average of $106.3 billion (or $285 million per company) on stock repurchases in 1995-1999, up from $25.9 billion in repurchases (or $69 million per company). This was equal to 44% of their combined net income (up from 23 percent of their combined net income in 1990-1994). Combined, the 500 companies in the S&P 500 Index in January 2008 repurchased $489 billion of their own stock in 2006, representing 62 percent of their net income, and $595 billion in 2007, representing 89 percent of their net income. Lazonick (2011) also notes the dramatic increase in stock repurchases after 2003, which may be linked to the upswing in excess credit after 2003 observable in Figure 3.

not even implied that there is causality between excess credit flows to the nonfinancial sectors and the trade balance at this level: this can also be viewed as a macroeconomic identity (the current account deficit equals the capital account surplus). The same holds for excess credit growth and net asset acquisition. But to the extent that variations in output financed by excess credit growth (through either or both of these channels) are countercyclical to the business cycle, excess credit growth smooths GDP. This is what we test.

TABLES AND FIGURES

Table 1: Descriptive Statistics

	Mean	**Std dev.**	**Skewness**	**Kurtosis**	**LM-Statistic**
1954Q3-1978Q4					
RGDP	0.0094	0.0109	-0.3512	3.5788	33.1762*** (12)
INF	0.0097	0.0064	0.8570	3.5780	-
EXCRED	0.0042	0.0380	-0.4203	7.5537	-
FR	0.0232	0.1858	-1.1955	9.2076	-
1984Q1-2008Q1					
RGDP	0.0076	0.0051	-0.1665	3.2697	3.5213* (1)
INF	0.0063	0.0024	0.6443	2.7108	-
EXCRED	0.0107	0.0352	-0.4955	2.8513	-
FR	-0.0133	0.1401	-0.6680	5.9591	-

Table 2: AR(p)-(A)Symmetric GARCH Models

	AR(2)-GARCH(1,1)	AR(2)-EGARCH(1,1)	AR(2)-TGARCH(1,1)
	Conditional Mean Equation		
μ	0.0080	0.0076	0.0077
	(0.0000)	(0.0000)	(0.0000)
φ_1	0.2319	0.2158	0.2209
	(0.0019)	(0.0033)	(0.0042)
φ_2	0.1816	0.2099	0.2064
	(0.0112)	(0.0034)	(0.0041)
	Conditional Variance Equation		
α_0	2.86E-06	-1.0175	3.72E-06
	(0.2584)	(0.0700)	(0.2122)
α_1	0.1903	0.3742	0.1053
	(0.0091)	(0.0028)	(0.2710)
β_1	0.7823	0.9257	0.7504
	(0.0000)	(0.0000)	(0.0000)
λ_1		-0.1433	
		(0.0587)	
γ_1			0.2292
			(0.0849)
	Residual Diagnostics		
Q(8)	3.5933	4.0708	4.5237
	(0.892)	(0.851)	(0.807)
$Q^2(8)$	13.952	15.854	17.634
	(0.083)	(0.045)	(0.024)
Q(12)	7.3480	8.9154	9.0317
	(0.834)	(0.710)	(0.700)
$Q^2(12)$	15.769	18.199	19.469
	(0.202)	(0.110)	(0.078)
SIC	-6.7314	-6.7262	-6.7198

Notes: Probability values are in parentheses. Q(p), Q^2(p) reflect the Ljung-Box statistic for remaining autocorrelation and remaining ARCH effects, respectively; SIC is the value for Schwarz Information Criterion.

Table 3: Granger Causality Tests

Testable Hypotheses	Pre-Great Moderation	During-Great Moderation
	Chi-square statistic	
	1954Q3-1978Q4	1984Q1-2008Q1
EXCRED does not Granger Cause σ_{dlrgdp}	0.3699 (0.5431)	6.1277 (0.0133)
σ_{dlrgdp} *does not Granger Cause EXCRED*	0.5543 (0.4566)	2.2550 (0.1332)
dlfr does not Granger Cause σ_{dlrgdp}	6.5031 (0.0108)	3.2901 (0.0697)
σ_{dlrgdp} *does not Granger Cause dlfr*	0.9065 (0.3410)	5.8772 (0.0153)
inf does not Granger Cause σ_{dlrgdp}	0.4652 (0.4952)	0.1057 (0.7451)
σ_{dlrgdp} *does not Granger Cause inf*	0.3841 (0.5354)	0.0003 (0.9869)
dlfr does not Granger Cause EXCRED	0.5396 (0.4626)	0.0301 (0.8622)
EXCRED does not Granger Cause dlfr	4.1389 (0.0419)	5.9126 (0.0150)
inf does not Granger Cause EXCRED	0.0007 (0.9787)	0.6197 (0.4312)
EXCRED does not Granger Cause inf	1.1327 (0.2872)	0.7175 (0.3970)
inf does not Granger Cause dlfr	0.6649 (0.4307)	4.0893 (0.0432)
dlfr does not Granger Cause inf	3.3500 (0.0672)	0.1686 (0.6814)

Notes: Probability values of the corresponding Chi-square statistics are in parentheses.

Table 4: Excess credit growth and output volatility: impulse response functions

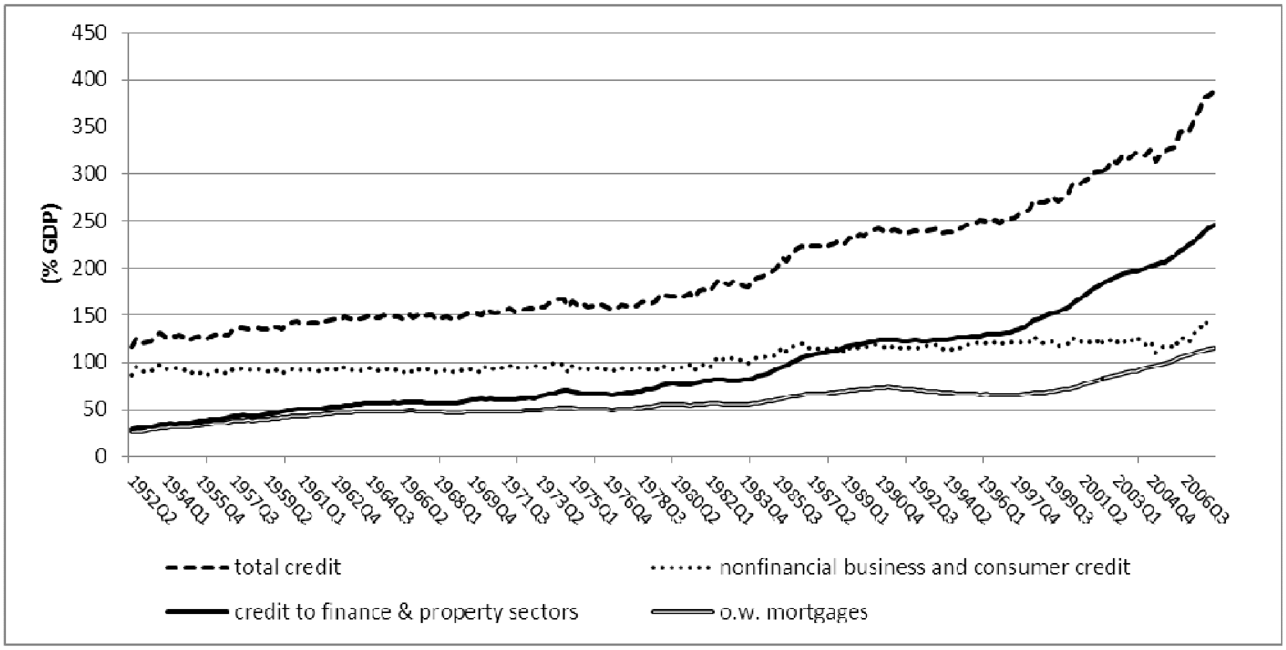
Results from impulse response functions	
Before the Great Moderation	*During the Great Moderation*
change in interest rate (-) => output volatility	excess credit growth (-) => output volatility
	excess credit growth (+) => change in interest rate
	inflation (+) => change in interest rate

Note: In the table, *x* (-) => *y* denotes that a one-standard deviation shock in variable *x* impacts negatively on the change of variable *y*. Similarly, *x* (+) => *y* indicates a positive impact.

Table 5: Excess credit growth and output volatility: forecast error variance decomposition

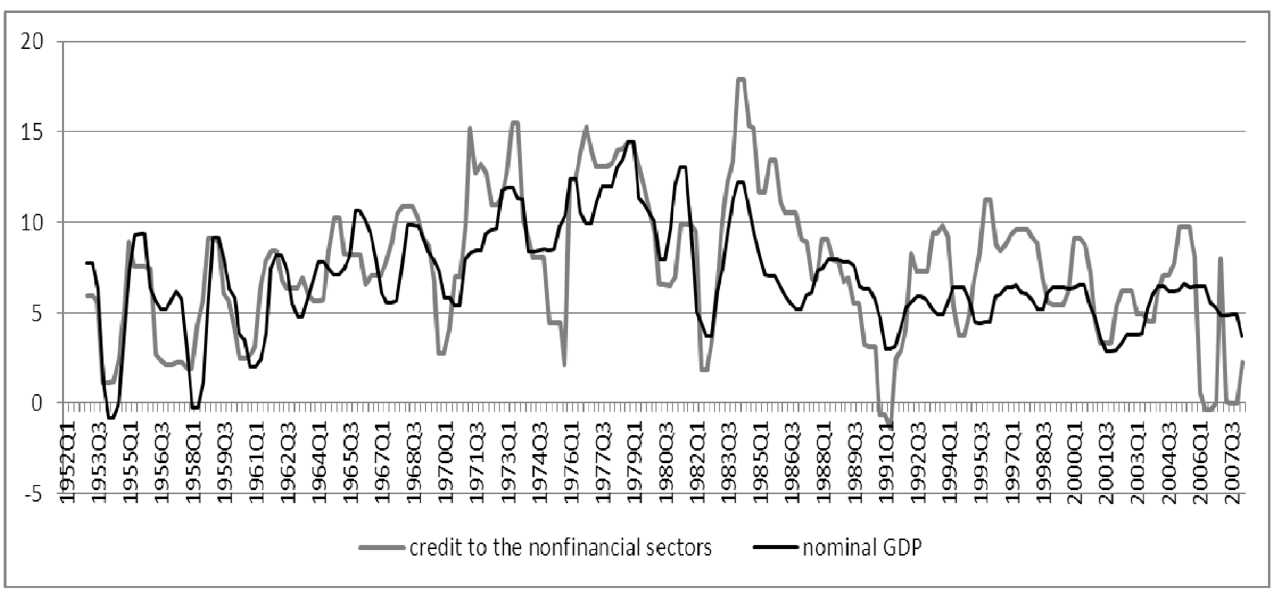
% of 12-quarters-ahead forecast error variance of output growth volatility explained by ...			
Before the Great Moderation		*During the Great Moderation*	
excess credit growth:	0.15%	excess credit growth:	18.15%
change in interest rate:	8.77%	change in interest rate:	5.91%
Inflation:	4.32%	Inflation:	0.05%

Figure 1: U.S. credit-to-GDP ratios (%), 1952Q1 – 2012Q1



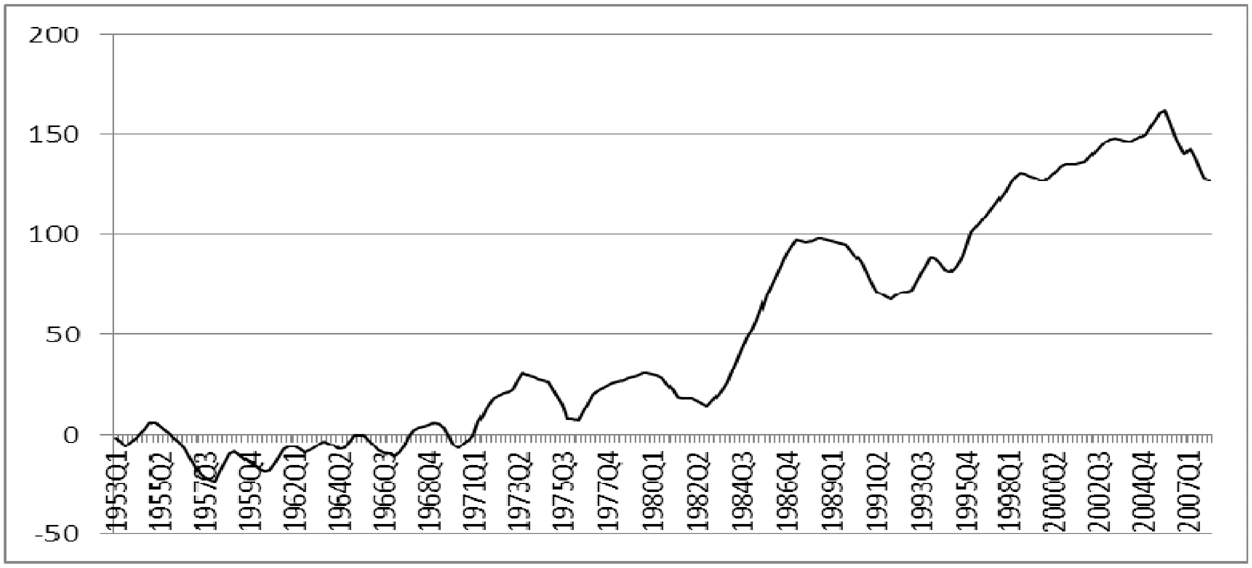
Source: Bureau of Economic Analysis, flow of funds data (Z tables).

Figure 2: Credit to the nonfinancial sectors and nominal GDP, 1952-2012



Source: Bureau of Economic Analyis. Note: Data are growth rates (in percent) of nominal Dollar figures. In this graph (but not in the analysis), time series have been smoothed by taking the median of the current, previous and next quarter.

Figure 3: Cumulative percentage point growth of "excess credit", 1952-2008



Source: Bureau of Economic Analyis

Figure 4: Impulse Responses to shocks during the Great Moderation (1984Q1-2008Q1)

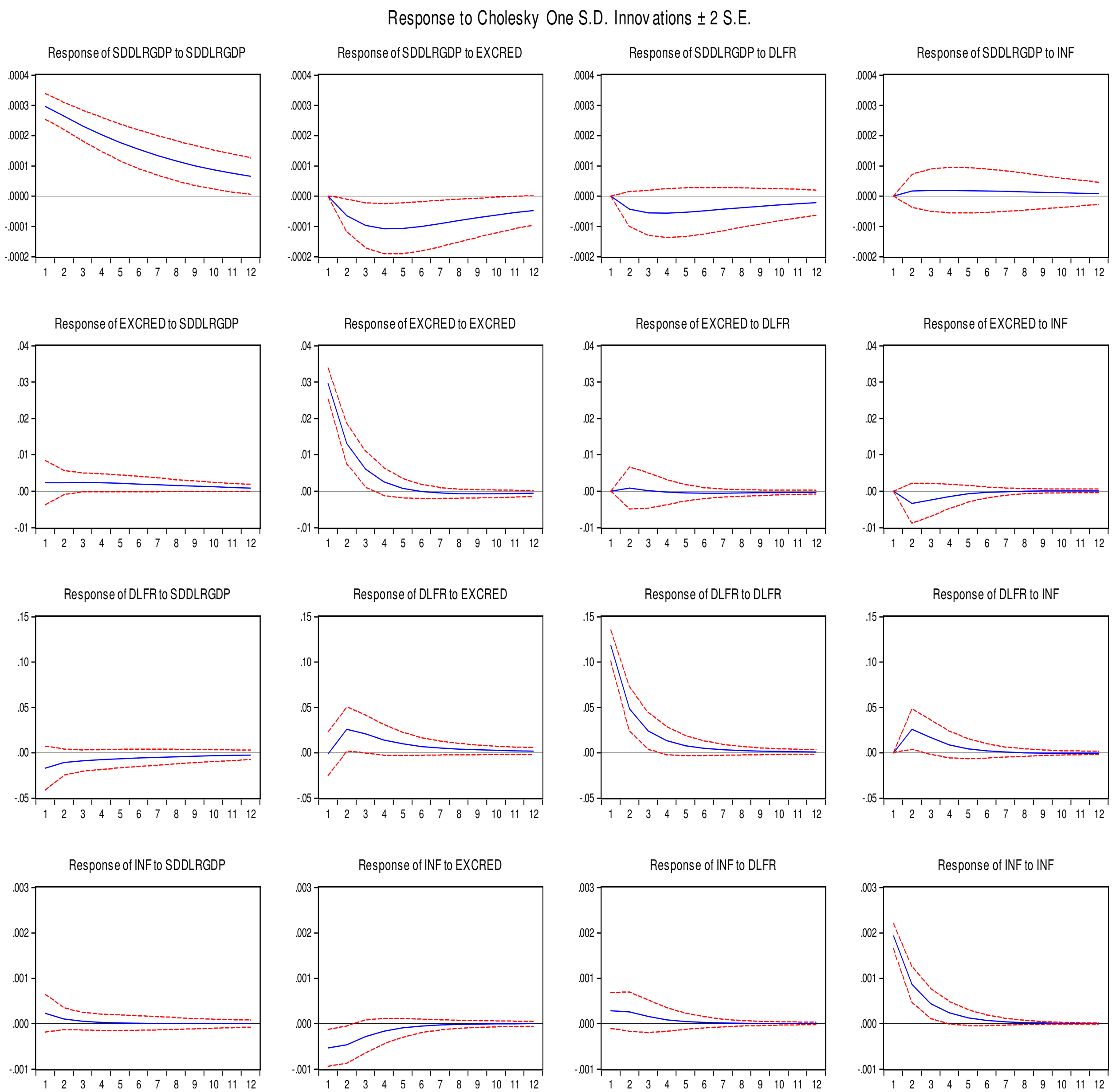


Figure 5: Impulse Responses to shocks before the Great Moderation (1954Q3-1978Q4)

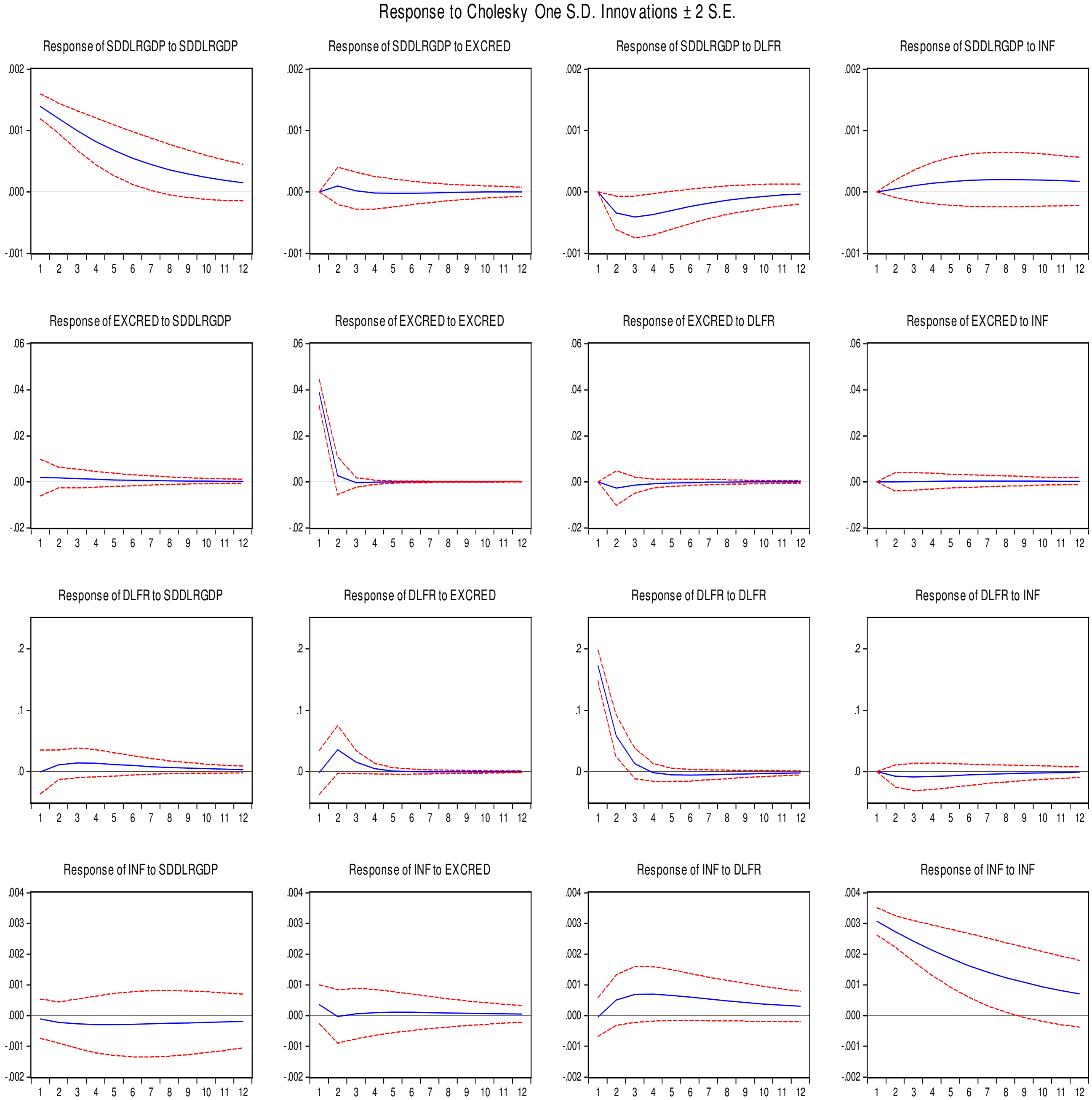


Figure 6: Variance Decomposition of the Variables during the Great Moderation (1984Q1-2008Q1)

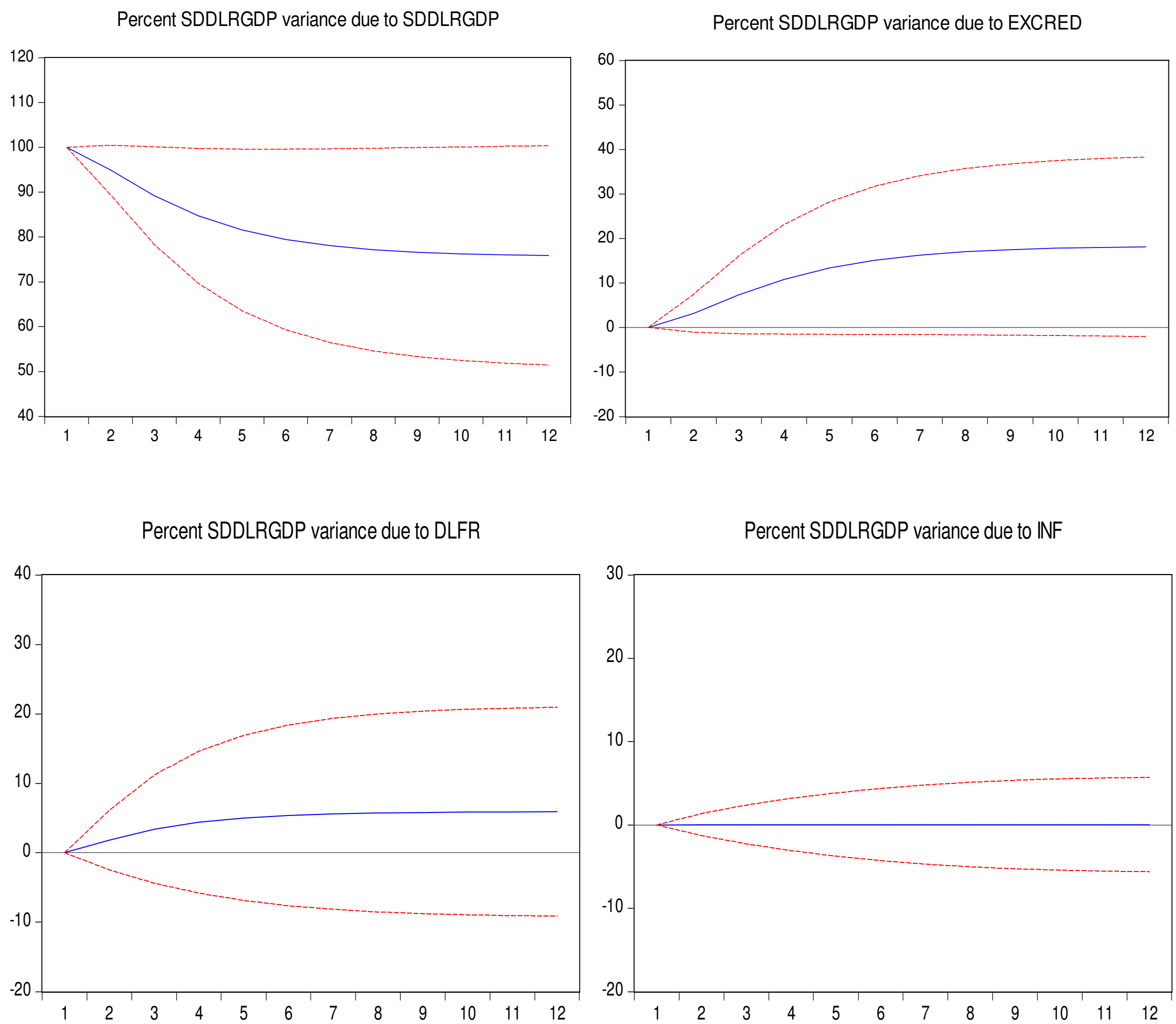


Figure 7: Variance Decompositions before the Great Moderation (1954Q3-1978Q4)

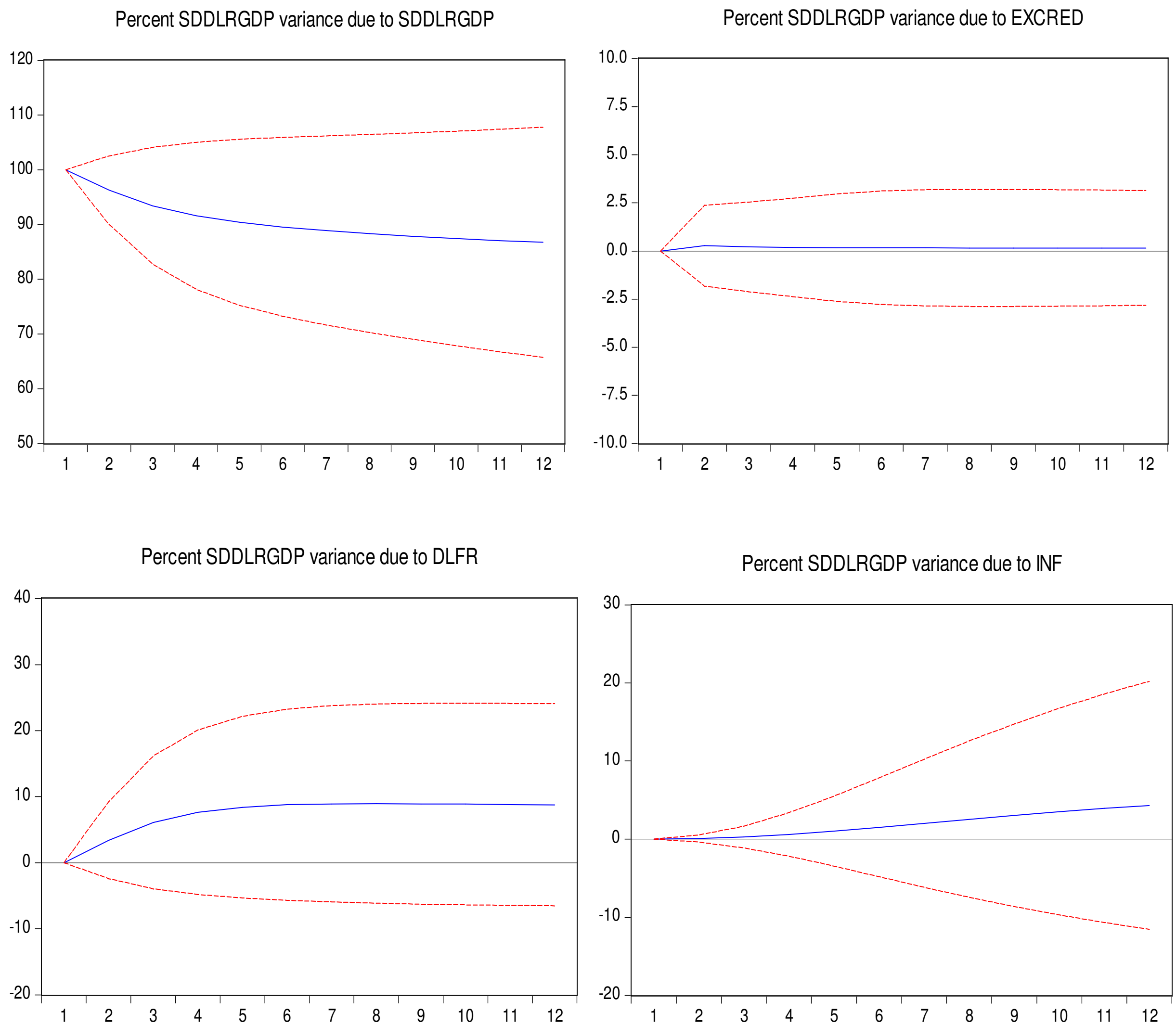
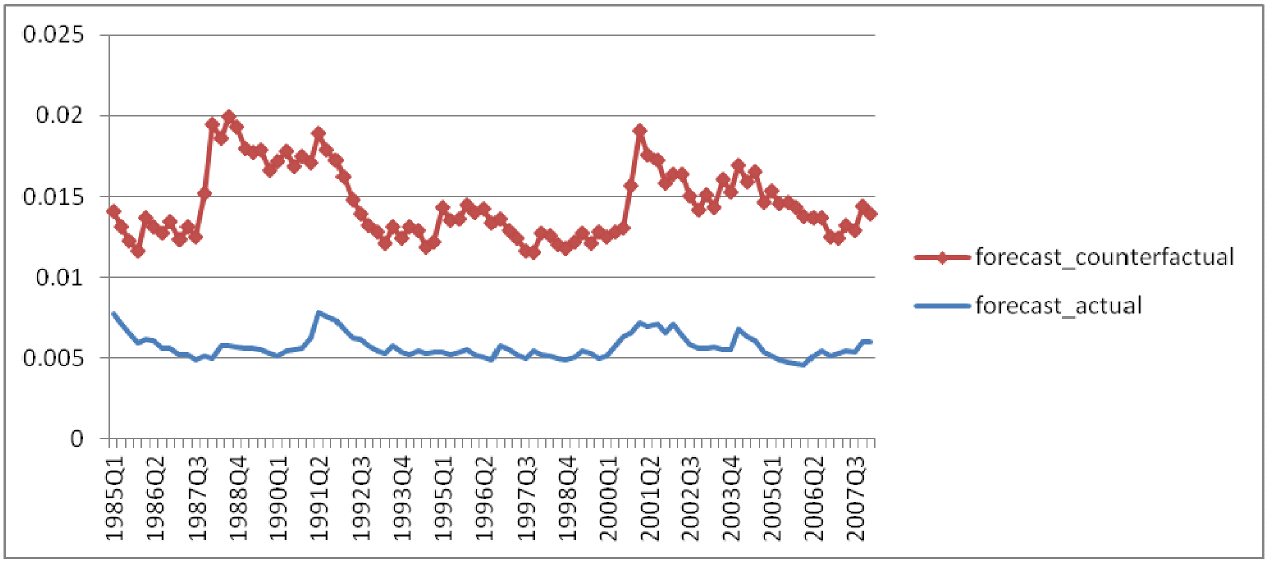


Figure 8: Counterfactual Forecast of Output Growth Volatility during the Great Moderation (1984Q1-2008Q1).



Note: Counterfactual forecasts are constructed by applying during-Great Moderation VAR parameter estimates to pre-Great Moderation variables values, in order to compute output volatility in each quarter.

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